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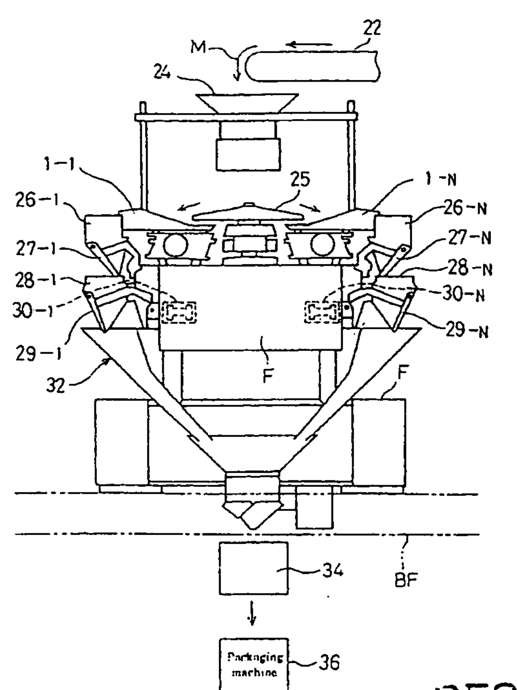
(54) **Control method and controller of vibrating feeder**

(57) A control method and a controller of a vibrating feeder which allow the vibrating feeder to have an excellent responsibility at the time of start thereof and to suppress the mechanical strength of the vibrating feeder by readily smoothing overshoots which might otherwise be caused by a transient response at the time of start are provided.

A feed-power is set at a level corresponding around to or higher than a target amplitude of the vibrating feeder 1 at the time of start thereof, so that it has the excellent responsibility at the time of start. Further, following to that, it is set at a level lower than that at least once, so that the overshoot at which the vibrating feeder 1 exceeds the target amplitude may be suppressed, thus allowing to reduce the mechanical strength of the vibrating feeder.

Fig.1



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Description

The present invention relates to a vibrating feeder, for instance for feeding articles in a weighing equipment or the like and to a method of controlling a vibrating feeder.

In a weighing equipment or the like for weighing articles, a vibrating feeder is used to feed the articles to a weighing mechanism. The vibrating feeder is connected to a vibrating mechanism composed of an electromagnet to which power is fed from an AC power supply, a movable part, leaf springs and the like. The vibrating feeder is vibrated by the vibrating mechanism. An AC power supply is selectively applied to the electromagnet. When current passes through the electromagnet, an attractive force is applied to the movable part. By controlling the firing angle of the applied voltage, the vibrating feeder is vibrated to feed the articles on the feeder.

In this case, the vibrating feeder obtains a large vibration force with less energy by the utilisation of resonance.

Referring to FIG. 3b, because the prior art vibrating feeder utilizes resonance, overshoots in which the amplitude of vibration exceeds a target amplitude W can occur. FIG. 3b illustrates such overshoots during a drive period AT which occurs between a start time t0 and a stop time tl. These overshoots are due to transient response at the start time t0. Due to the occurrence of the overshoots, there has been a problem that the mechanical strength of the vibrating components has to be increased.

Although it is conceivable to detect the amplitude of the vibrating feeder to control it within the target amplitude W, a unit for that end has to be added, which complicates the structure and increases the cost.

On the other hand, a control method in which the overshoot is suppressed by gradually increasing the amount of power fed to the vibrating mechanism when it is started is known (Japanese Utility Model Publication No. 58-16970). However this method has the problem that the target amplitude W is reached some time after the start time.

In accordance with a first aspect of the present invention there is provided a method of controlling a vibrating feeder comprising applying a drive signal to a vibrating mechanism connected to the vibrating feeder at a first predetermined power level; and subsequently applying a drive signal to the vibrating mechanism at a second predetermined power level which is greater than zero and lower than the first predetermined power level whereby the amplitude of vibration of the vibrating feeder converges towards a target amplitude.

The first aspect of the present invention provides an efficient and a simple method of controlling a vibrating feeder such that the amplitude of vibration is controlled to converge towards a target amplitude.

The method according to the present invention may be carried out at any time in a control procedure. For instance the method may be employed during a drive period to change the target amplitude. Alternatively the method may be employed at the end of a drive period. Preferably however the method is carried out at the start of a drive period, typically to control transient response at the start of the drive period. Typically the drive signal is applied to the vibrating feeder in a series of drive periods, and the method is carried out at the start of each drive period.

The vibrating feeder may be controlled with feedback, but preferably the method comprises an open-loop correction method, i.e. the first and second power levels are determined independently of the response of the vibrating mechanism to the applied drive signal.

Typically the first power level corresponds to a steady-state amplitude of vibration of the vibrating feeder at or above the target amplitude. That is, if the vibrating feeder was driven at the first power level for a long period until it reaches a steady-state amplitude, then that amplitude would be at or above the target amplitude. This ensures that the amplitude of vibration converges rapidly towards the target amplitude.

Typically the second power level corresponds to a steady-state amplitude of vibration of the vibrating feeder below the target amplitude. This ensures that the amplitude of vibration of the vibrating feeder does not overshoot the target amplitude.

The drive signal may be generated in any suitable manner. In a preferable embodiment the drive signal is generated by switching a power supply signal.

Typically the drive signal is cyclical, and is applied to the vibrating mechanism at the first and/or second power level over a predetermined number of cycles.

In accordance with a second aspect of the present invention there is provided apparatus for controlling a vibrating feeder connected to a vibrating mechanism, the apparatus comprising means for applying a drive signal to the vibrating mechanism at a first predetermined power level, and means for subsequently applying the drive signal to the vibrating mechanism at a second predetermined power level which is greater than zero and lower than the first predetermined power level whereby the amplitude of vibration of the vibrating feeder converges towards a target amplitude.

Any suitable means for generating the drive signal may be employed. However, in a preferable embodiment the apparatus further comprises a switching element for switching a power supply signal to generate the drive signal; and firing angle control means for controlling the power level by controlling the firing angle of the switching element.

Typically the apparatus further comprises control pattern storage means for storing a control pattern, wherein the firing angle control means controls the switching element in accordance with the control pattern.

In accordance with a third aspect of the present invention there is provided a method of controlling a vi-

brating feeder comprising applying a drive signal having a phase to a vibrating mechanism connected to the vibrating feeder at a first phase; and subsequently applying the drive signal to the vibrating mechanism at a second phase which is different to the first phase, whereby the amplitude of vibration of the vibrating feeder converges towards a target amplitude.

The third aspect of the present invention provides an alternative method of controlling a vibrating feeder, ie. by varying the phase of the drive signal.

The method may be carried out at any time in a control procedure. For instance the method may be employed during a drive period to change the target amplitude. Alternatively the method may be employed at the start of a drive period. Preferably however the method is carried out when the vibrating feeder is to be stopped. In this case the target amplitude is zero. This ensures a rapid reduction of amplitude when the vibrating feeder is to be stopped.

A feedback method may be employed, but preferably the method comprises an open-loop correction method, i.e. the first and second phases are determined independently of the response of the vibrating mechanism to the applied drive signal.

Typically the power supply signal is applied to the vibrating mechanism in a series of drive periods, and the method is carried out at the end of each drive period.

The first and second phases may be offset by any chosen amount, but preferably the second phase is offset from the first phase by half a cycle. This ensures that the vibration is rapidly stopped.

Typically the drive signal is generated by switching a power supply signal.

Typically the drive signal is applied to the vibrating feeder at the second phase over a predetermined number of cycles.

In accordance with a fourth aspect of the present invention there is provided apparatus for controlling a vibrating feeder connected to a vibrating mechanism, the apparatus comprising means for applying a drive signal having a phase to the vibrating mechanism at a first phase, and means for subsequently applying the drive signal to the vibrating mechanism at a second phase which is different to the first phase whereby the amplitude of vibration of the vibrating feeder converges towards a target amplitude.

Typically the apparatus comprises a switching element for switching a power supply signal to generate the drive signal; and firing angle control means for controlling the phase of the drive signal by controlling the firing angle of the switching element.

Typically the apparatus further comprises zero-cross detecting means for detecting a zero-cross point of the power supply signal; and phase switching means for switching the phase of the drive signal in response to the detected zero-cross point.

In all cases the drive signal may be produced or derived from any suitable power supply, such as an AC power supply or a pulsating current power supply.

In a preferable embodiment the methods according to both the first and third aspects of the present invention are combined. In this case the methods may be carried out simultaneously (i.e. the first and second power levels may also correspond with first and second phases). Alternatively the methods may be carried out sequentially in any order. The methods according to the first and third aspects of the present invention are typically employed to control transient response during a sequence of drive periods. Each method may be employed one or more times in a drive period.

Similarly the apparatus according to the second and fourth aspects are preferably combined in a single apparatus.

In all cases the method and apparatus is typically employed in a weighing device in which the vibrating feeder is used to feed articles. For instance the vibrating feeder may comprise a distributing feeder in a combination weighing device. Alternatively the vibrating feeder may feed articles into a pool hopper or onto a weighing table.

A number of embodiments of the present invention will now be described with reference to the accompanying drawings, in which:-

FIG. 1 is a side view showing a combination weighing equipment using a vibrating feeder according to an embodiment of the present invention;

FIG. 2 is a structural view showing the controller of the vibrating feeder according to an embodiment of the present invention;

FIG. 3a is a chart showing states of amplitudes of a vibrating feeder according to the second and fourth aspects of the present invention;

FIG. 3b is a chart showing states of amplitudes of a conventional vibrating feeder;

FIG. 4 is a chart showing operation timings of the vibrating feeder;

FIG. 5 is a table showing firing angle control patterns in starting the vibrating feeder;

FIG. 6A(a) is a graph illustrating the power supply signal voltage, the load current and the drive signal voltage;

FIG. 6A(b) illustrates the ON/OFF periods of the switch;

FIG. 6A(c) illustrates the firing signal output by the firing angle control means;

FIG. 6A(d) illustrates the zero-cross signal output by the zero-cross detecting means;

FIG. 6A(e) illustrates the starting signal output by controller 60;

FIGS. 6B(a)-(e) show corresponding signals with a delayed firing angle;

FIGS. 6C(a)-(e) illustrate a further alternative in which the time ε falls before a positive - to - negative zero-cross signal;

FIG. 7 is a chart showing a state in controlling firing

angles of a feed-voltage;

FIG. 8 is a chart showing a state in controlling the feed-voltage when the vibrating feeder is stopped; and

FIG. 9 is a side view showing a weighing equipment using the controller of the vibrating feeder according to another embodiment.

FIG. 1 is a schematic side view showing a combination weighing equipment using a vibrating feeder controller according to the present invention. This equipment is supported on a base frame BF. Articles M sent from a supply belt 22 are collected at the centre of a vibrating distributing feeder 25 via a supply chute 24. A number of vibrating feeder systems 1 (1-1 through 1-N) are disposed radially around the outer periphery of the distributing feeder 25 so as to receive the articles M distributed by the distributing feeder 25. The vibrating feeder systems 1 vibrate with a predetermined amplitude and number of cycles of vibration to feed the articles M in the radial direction.

Next, the articles M are fed to pool hoppers 26 (26-1 through 26-N) by the vibrating feeder systems 1. The articles M are pooled temporarily in pool hoppers 26 and are then fed into weighing hoppers 28 (28-1 through 28-N) by opening the discharge gates 27 (27-1 through 27-N) of the pool hoppers 28. Weight detecting means 30 (30-1 through 30-N) such as a load cell measures the weight of the articles M put into each weighing hopper 28 and outputs a weight detection signal. Then, combinational computation is performed based on the weight detection signals to select the weighing hopper 28 in which the combinational weight of the articles is closest to a target weight. A discharge gate 29 (29-1 through 29-N) of that weighing hopper is opened and the articles are collected at a collecting chute 32 to be discharged to a discharge chute 34. The discharged articles M are packed by a packing equipment 36 as packed goods having the target weight.

FIG. 2 is a structural view showing the controller of a vibrating feeder according to an embodiment of all aspects of the present invention. FIG. 2 shows a vibrating feeder system 1 comprising vibrating feeder 1b (which is in the form of a trough) and vibrating mechanism la, switching element 4, control pattern storage means 12, zero-cross detecting means 16 and a CPU 8.

The CPU 8 comprises a cycle counter 6, firing angle control means 10 and opposite phase switching means 18. The CPU 8 receives START/STOP signals from a controller 60.

The vibrating feeder 1b is connected to the vibrating mechanism la. The vibrating mechanism la comprises an electromagnet 3 to which power is fed from a commercial AC power supply 2 via the serially connected switch 4 which is typically a solid state relay (SSR). The signal which is fed into the SSR 4 from the power supply 2 is referred to herein as a power supply signal. The signal which is output from SSR 4, and applied to the electromagnet 3, is referred to herein as a drive signal.

Lower ends of a pair of leaf springs 7 at the front and rear respectively of the electromagnet 3 are fixed to a base B attached to a frame F of the weighing equipment via a vibration-proof elastic body S. A bracket BR is connected at the upper ends of the leaf springs 7 and a movable iron core 5 which faces the electromagnet 3 is fixed to this bracket BR. The vibrating mechanism la vibrates the vibrating feeder 1b to feed articles M on the vibrating feeder 1b. The vibrating mechanism la is driven by turning On/Off the power fed from the AC power supply 2 by the switching element 4. This enables the power and phase of the drive signal to be controlled by controlling the switching of the SSR 4. The natural frequency of the vibrating feeder system 1 is set around the frequency of the AC power supply to obtain a large amplitude of the vibrating feeder 1b with low power.

The operation of this system will be explained below.

FIG. 4 shows operation timings of the vibrating system 1 (FIG. 4a), the discharge gate 27 of the pool hopper (FIG. 4b) and the discharge gate 29 of the weighing hopper 28 (FIG. 4c). Referring to FIG. 4(c), when the combinational computation has been performed the discharge gate 29 of the weighing hopper 28 is opened to discharge the articles M in FIG. 1, and the discharge gate 29 is then closed at time α.

Referring to FIG. 4(b), because there is a fall time θ during which articles fall from the pool hopper 26 to the weighing hopper 28, the discharge gate 27 of the pool hopper 26 is opened at timing β which is earlier by the fall time θ than the time α when the discharge gate 29 is closed. The discharge gate 27 is closed at time γ after discharging the articles M stored in the pool hopper 26 therefrom.

Similarly, because there is a fall time ϕ during which articles fall from the vibrating feeder 1b to the pool hopper 26, the vibrating feeder 1b is started at time ε (t0 in FIG. 3) which is earlier by fall time ϕ than the time γ. The vibrating feeder system 1 is stopped at time λ (tl in FIG. 3).

Thus, the discharge gate 27 of the pool hopper is open for part of the time during which the discharge gate 29 of the weighing hopper is also open, and the vibrating feeder 1b is started to vibrate when the discharge gate 27 of the pool hopper is open. This increases the overlap between the operation timing of the vibrating feeder 1b and the timings for opening/closing the discharge gate 27 of the pool hopper in order to obtain sufficient feed amount of the vibrating feeder 1.

(1) When Vibrating Feeder System 1 is Started:

FIG. 6 shows states in controlling the firing angles of the feed-voltage. Referring to FIG. 6A, at start time ε the controller 60 outputs a starting signal shown in FIG. 6A(e) to firing angle control means 10. Immediately after start time ε the firing angle control means 10 receives a

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zero-cross signal 40 and, after an amount of time determined by the firing angle, outputs a firing signal 42. This causes the SSR 4 to switch ON. The firing angle control means is adopted to output a firing signal 42 after every other zero-cross signal, i.e. after zero-cross signals 40 and 45 (labelled A), but not after zero-cross signals 46 and 47 (labelled B). It is noted that in (a) of FIG. 6A, the load current is phase shifted from the load voltage because the electromagnet 3 (FIG. 2) of the vibrating mechanism la includes a coil which is an inductive load. Meanwhile the SSR 4 continues to permit the flow of current until it becomes zero even if the firing signal 42 is turned OFF. Thus the SSR 4 is actually ON until the current becomes zero as shown in FIG. 6A(b). The drive signal voltage is indicated by the hashed portions of FIG 6A(a). FIG 6A(d) shows zero-cross signals caused by successive zero-crossings of the power supply voltage, as detected by the zero-cross detecting means 16. The power per cycle delivered to the vibrating mechanism is substantially proportional to the length of the ON period of the SSR4.

FIG. 6B illustrates an alternative example when the firing angle is increased from the firing angle illustrated in FIG. 6A. As a result the firing signal 43 is delayed in comparison to the firing signal 42, and the power delivered by the SSR 4 is reduced.

FIG. 6C illustrates the situation when the start time ε occurs before a positive-to-negative zero-cross signal 44. In this case the current pulse 50 is negative, but the force exerted by the electromagnet 3 on the iron core is still attractive over the ON cycle of the SSR 4.

After receiving a starting signal output from the controller 60 of the whole weighing equipment at the abovementioned timing ε, the firing angle control means 10 in FIG. 2 reads the control pattern from the control pattern storage means 12 and resets the cycle counter 6. Then, it sends a firing signal to the SSR 4 according to the control pattern and receives a count input from the cycle counter 6 to monitor timings for switching the control pattern in which each number of cycles is set respectively. When the switching timing comes, it resets the counter 6 and switches to the next control pattern to send a firing signal to the SSR 4 in accordance with that control pattern. The SSR 4 turns ON/OFF based on the transmitted firing signal to control the power fed to the vibrating mechanism 1a.

FIG. 5 shows three examples of this control pattern.

The pattern control operation of the firing angle control means 10 will be explained below with reference to FIGS. 7 and 5.

FIG. 7 illustrates the power supply signal voltage and the drive signal voltage (hashed portions) during a drive period AT. In FIG. 7, the firing angle control means 10 first reads a first firing angle al and a first number of cycles bl from the control pattern in FIG. 5a. That is, as shown by 101 in FIG. 7, it controls the drive signal fed to the vibrating mechanism la across the first number of cycles b1 (e.g. 4 times) corresponding to a count input from the cycle counter 6 at the first firing angle al. Next, as shown by 102 in FIG. 7, the drive signal is controlled across a second number of cycles b2 (e.g. 4 times) at a second firing angle a2 which is delayed from the first firing angle a1. Following that, as shown by 103 in the figure, the drive signal is controlled across a predetermined number of cycles b3 at a third firing angle a3 which is advanced from the second firing angle a2.

The resulting amplitude of vibration of the vibrating feeder 1b is shown in FIG. 3a. The vibrating feeder system 1 is driven at first over b1 cycles with a firing angle al. The numbers a1 and b1 are suitably chosen such that the amplitude of vibration approaches the target amplitude after b1 cycles. Because the firing angle al corresponds to a steady-state amplitude around or higher than the target amplitude C, the amplitude of the vibrating feeder 1b increases quickly. Following that, it is driven over b2 cycles with a firing angle a2, where a2 corresponds to a steady-state amplitude which is less than the target amplitude C to suppress overshoot. Thereafter, it is driven at the firing angle a3 (third level of the drive signal power) which corresponds to the steady-state target amplitude C not to cause any overshoot again. Thus, when the amplitude of the vibrating feeder 1b is controlled by the control pattern, it is suppressed or maintained within the target amplitude C without causing any overshoot which is otherwise caused in the past as shown in FIG. 3b. It is noted that the firing angles al through a3 in controlling the drive signal are increased/decreased corresponding to an amount of the articles M to be put into the pool hopper 26 in FIG. 1.

FIGS. 5b and 5c illustrate alternative control patterns. The fourth firing angle a4 is advanced from the second firing angle a2.

Due to lack of overshoot, the mechanical strength of the vibrating feeder system 1 does not need to be increased as in the past. It is noted that the distributing feeder 25 may also be controlled in the same manner as the vibrating feeder 1b so as to reduce the mechanical strength thereof.

(2) When Vibrating Feeder System 1 is Stopped:

Next, a case when the vibrating feeder 1b is stopped will be explained with reference to FIG. 8. Hitherto, the vibrating feeder 1b has been left to natural attenuation of vibration when it is to be stopped. However, in the combination weighing equipment illustrated in FIG. 1, it is necessary to reduce the amplitude of the vibrating feeder 1b immediately after a drive period AT in order to fix the amount of articles M to be supplied and to improve the weighing accuracy. The drive signal is controlled in the present system so as to quickly reduce the amplitude of the vibrating feeder 1b when it is to be stopped. The operation of the vibrating feeder 1b when it is to be stopped will be explained below.

When the vibrating feeder 1b has fed a predeter-

mined amount of the articles M to the pool hopper 26, its vibrating operation is to be stopped (tl in FIG. 3). At this time the controller 60 sends a stopping signal to firing angle control means 10. On receipt of the stopping signal, the firing angle control means 10 sends a switching signal S1 to the opposite phase switching means 18. On receipt of switching signal S1 the opposite phase switching means 18 commands the cycle counter 6 to count the opposite signal, for example from A to B. Thus from time t2 the cycle counter 6 and firing angle control means 10 switch to an opposite phase, ie. the cycle counter 6 counts every positive-to-negative zero-cross signal B and the firing angle control means 10 outputs a firing signal after every positive-to-negative zero-cross signal B.

As a result, after time t2 the phase of the drive signal is opposite from that of the drive signal when it is driven in the drive period AT. After a predetermined number of opposite phase cycles (for instance two or three cycles) the firing angle control means 10 then stops sending firing signals.

Because the SSR 4 reverses the phase of the drive signal immediately after tl, the vibrating feeder 1b is applied with energy which causes the vibrating feeder to vibrate with the opposite phase from that during driving, thus attenuating the vibration rapidly.

Thereby, as shown by 106 in FIG. 3a, the amplitude of the vibrating feeder 1b which has been C at the time of driving is reduced to C/4 immediately after the stop thereof, so that the vibrating feeder 1b will not feed articles M to the pool hopper 26 by the remaining attenuating vibration after time tl. It is noted that a number of fine wave crests represents a number of times of vibration. Further, because the vibrating feeder 1b which has been attenuated naturally in the past as shown in FIG. 3b is quickly attenuated, the attenuation time is shortened and the weighing speed may be improved.

It is noted that when the vibration cannot be attenuated quickly by sending two or three opposite phase signals because the target amplitude value of the vibrating feeder 1b is high and the amplitude is large, more opposite phase signals may be transmitted.

Although the apparatus has been used in combination weighing equipment in the present embodiment, it may also be used for a vibrating feeder of a balancing weighing equipment as illustrated in FIG. 9. As shown in FIG. 9, a fixed amount of articles M is obtained by detecting the weight of the articles M supplied to a weighing table D mounted on weight detecting means 30. The present invention allows a fixed amount of articles M to be supplied from the vibrating feeder 1b to the weighing table D.

It is noted that although a commercial AC power supply 2 has been used in the present embodiment, a power supply having a predetermined frequency generated by an inverter may be also used. Also a pulsed current supply may be used.

Claims

1. A method of controlling a vibrating feeder (1b) comprising applying a drive signal to a vibrating mechanism (1a) connected to the vibrating feeder at a first predetermined power level (a1); and subsequently applying the drive signal to the vibrating mechanism (la) at a second predetermined power level (a2) which is greater than zero and lower than the first predetermined power level whereby the amplitude of vibration of the vibrating feeder (1b) converges towards a target amplitude (C,W).

2. A method according to claim 1 wherein the drive signal is applied to the vibrating mechanism (1a) at the first and second predetermined power levels at the start (t0) of a drive period (AT).

3. A method according to claim 1 or 2 wherein the first and second power levels are determined independently of the response of the vibrating mechanism (1a) to the applied drive signal.

4. A method according to any of the preceding claims wherein the first power level corresponds to a steady-state amplitude of vibration of the vibrating feeder (1b) at or above the target amplitude (C,W).

5. A method according to any of the preceding claims wherein the second power level corresponds to a steady-state amplitude of vibration of the vibrating feeder (1b) below the target amplitude (C,W).

6. A method according to any of the preceding claims, wherein the drive signal is generated by switching a power supply signal.

7. A method according to any of the preceding claims, wherein the drive signal is cyclical, and is applied to the vibrating mechanism (1a) at the first power level over a predetermined number (b1) of cycles.

8. A method according to any of the preceding claims, wherein the drive signal is cyclical, and is applied to the vibrating mechanism (1a) at the second power level over a predetermined number (b2) of cycles.

9. Apparatus for controlling a vibrating feeder (1b) connected to a vibrating mechanism, the apparatus comprising means (4,8) for applying a drive signal to the vibrating mechanism at a first predetermined power level (a1), and means (4,8) for subsequently applying the drive signal to the vibrating mechanism at a second predetermined power level (a2) which is greater than zero and lower than the first predetermined power level whereby the amplitude of vibration of the vibrating feeder converges towards a

target amplitude (C,W).

10. Apparatus according to claim 9 further comprising a switching element (4) for switching a power supply signal to generate the drive signal; and firing angle control means (10) for controlling the power level by controlling the firing angle of the switching element (4).

11. Apparatus according to claim 10 further comprising control pattern storage means (12) for storing a control pattern wherein the firing angle control means (10) controls the switching element (4) in accordance with the control pattern.

12. A method of controlling a vibrating feeder (1b) comprising applying a drive signal having a phase to a vibrating mechanism (1a) connected to the vibrating feeder at a first phase; and subsequently applying the drive signal to the vibrating mechanism (1a) at a second phase which is different to the first phase, whereby the amplitude of vibration of the vibrating feeder converges towards a target amplitude.

13. A method according to claim 12 wherein the drive signal is applied to the vibrating mechanism (1a) at the first and second phases when the vibrating feeder (1b) is to be stopped, and wherein the target amplitude is zero.

14. A method according to claim 12 or 13 wherein the first and second phases are determined independently of the response of the vibrating mechanism to the applied drive signal.

15. A method according to any of claims 12 to 14 wherein the second phase is offset by half a cycle from the first phase.

16. A method according to any of claims 12 to 15 wherein the drive signal is generated by switching a power supply signal.

17. A method according to any of claims 12 to 16, wherein the drive signal is applied to the vibrating feeder at the second phase over a predetermined number of cycles.

18. Apparatus for controlling a vibrating feeder (1b) connected to a vibrating mechanism (1a), the apparatus comprising means (4,8) for applying a drive signal to the vibrating mechanism at a first phase, and means (4,8) for subsequently applying the drive signal to the vibrating mechanism at a second phase which is different to the first phase whereby the amplitude of vibration of the vibrating feeder converges towards a target amplitude.

19. Apparatus according to claim 18 further comprising a switching element (4) for switching a power supply signal to generate the drive signal; and firing angle control means (10) for controlling the phase of the drive signal by controlling the firing angle of the switching element (4).

20. Apparatus according to claim 19 further comprising zero-cross detecting means (16) for detecting a zero-cross point (t2) of the power supply signal; and phase switching means (18) for switching the phase of the drive signal in response to the detected zero-cross point (t2).

21. A method of controlling a vibrating feeder (1b) according to any of claims 1 to 8 and at least one of claims 12 to 17.

22. Apparatus according to any of claims 9 to 11 in combination with apparatus according to any of claims 18 to 20.

23. A weighing device for weighing articles comprising a vibrating feeder for feeding the articles, and apparatus for controlling the vibrating feeder according to any of claims 9 to 11, 18 to 20 or 22.

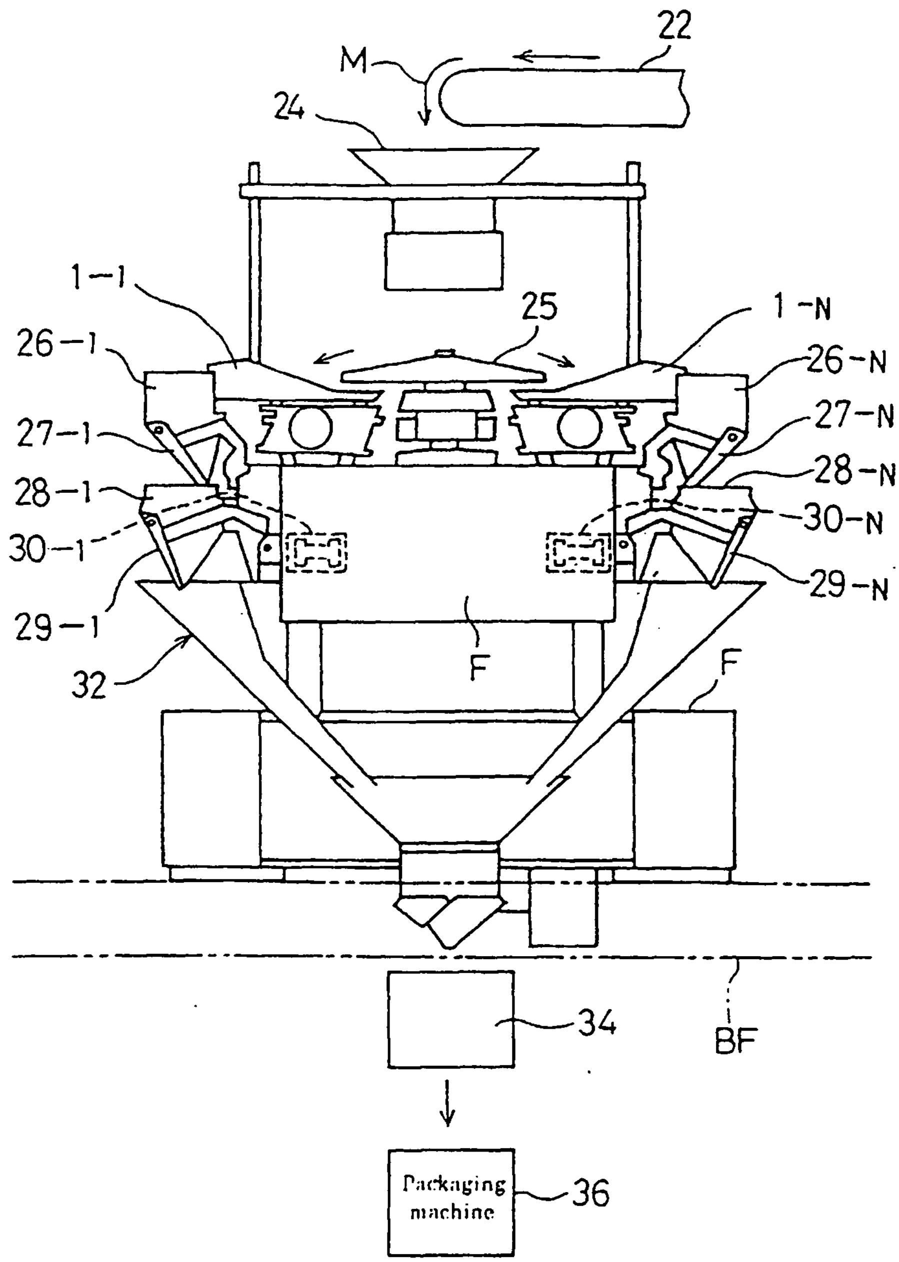
24. Apparatus according to claim 23 comprising one or more distributed vibrating feeders each of which is controlled by apparatus according to any of claims 9 to 11, 18 to 20 or 22; one or more pool hoppers into which articles are fed by a respective distributed vibrating feeder; and one or more weighing hoppers to which the articles are fed from a respective pool hopper.

25. Apparatus according to claim 23 or 24 wherein the vibrating feeder comprises a distributing feeder which distributes the articles towards a plurality of combination weighing devices.

26. Apparatus according to claim 23 further comprising a weighing table, wherein the vibrating feeder feeds the article onto the weighing table.

27. Apparatus according to any of claims 9 to 11, 18 to 20 or 23 to 27 wherein the vibrating feeder feeds a fixed amount of articles during a drive period.

Fig. 1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27−N
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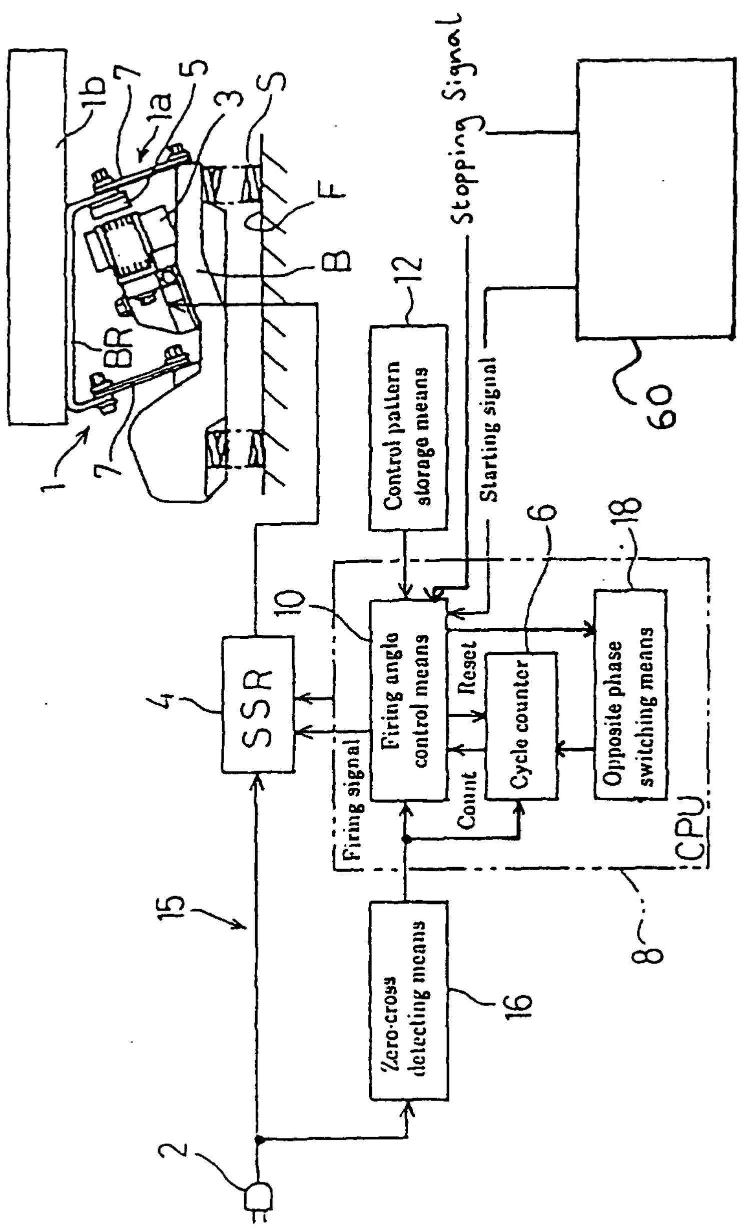
F
34
BF
Packaging machine
36

Fig.2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1a
5
3
S
F
B
BR
7
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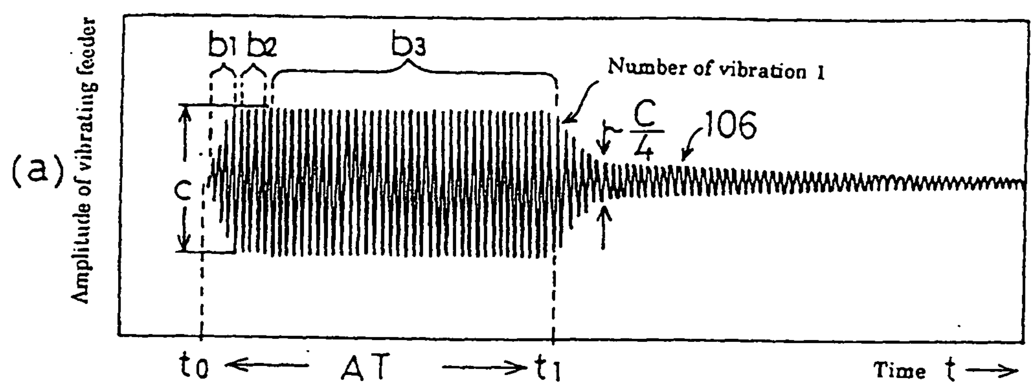
12
Control pattern storage means
Starting signal
60
6
18
10
Firing angle control means
Reset
Cycle counter
Opposite phase switching means
Count
Firing signal
SSR
4
CPU
15
8
Zero-cross detecting means
16
2

Fig.3


(a)
Amplitude of vibrating feeder
b1
b2
b3
Number of vibration 1
C
C/4
106
t0
AT
t1
Time t

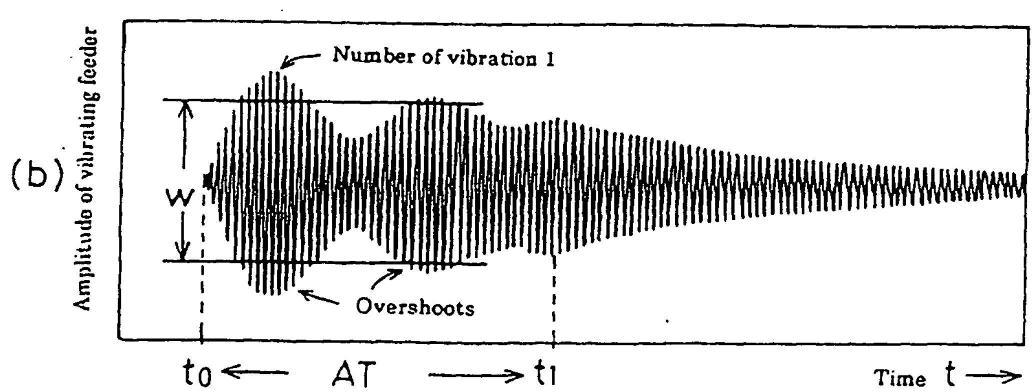

(b)
Amplitude of vibrating feeder
Number of vibration 1
W
Overshoots
t0
AT
t1
Time t

Fig.4

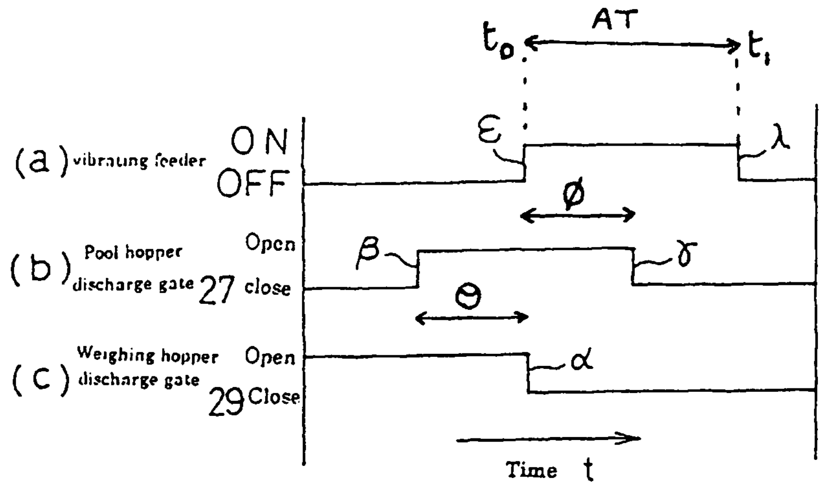


Fig.5

(a)

Number of cycles	Firing angle (Amplitude)
b 1	a1
b 2	a2
b 3	a3

(b)

Number of cycles	Firing angle (Amplitude)
b1	a1
b2	a2

(c)

Number of cycles	Firing angle (Amplitude)
b1	a 1
b2	a 2
b4	a 4
b3	a 3

【 Fig.6A 】

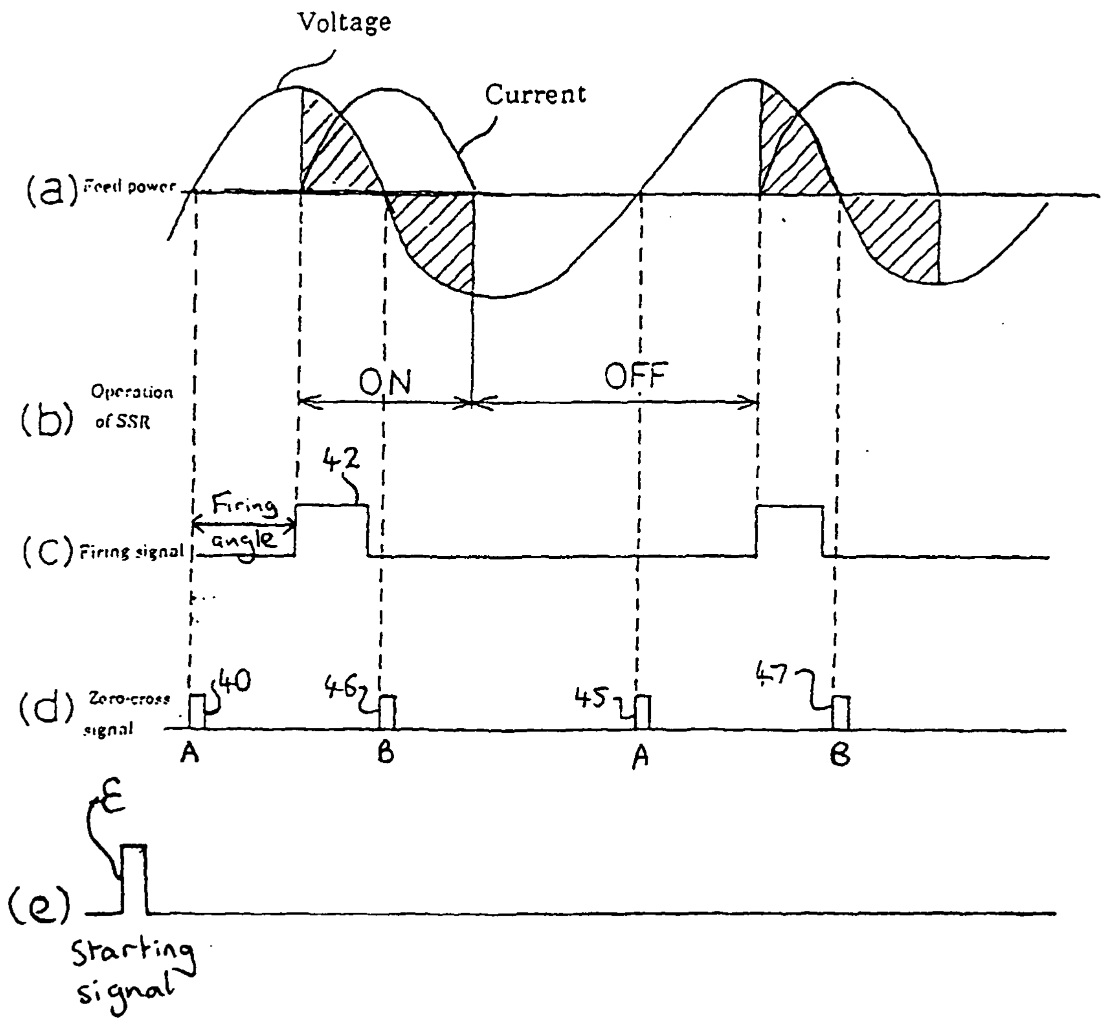

Voltage
Current
(a) Feed power
(b) Operation of SSR
ON
OFF
(c) Firing signal
Firing angle
42
(d) Zero-cross signal
40
46
45
47
A
B
A
B
(e)
E
Starting signal

Fig 6B

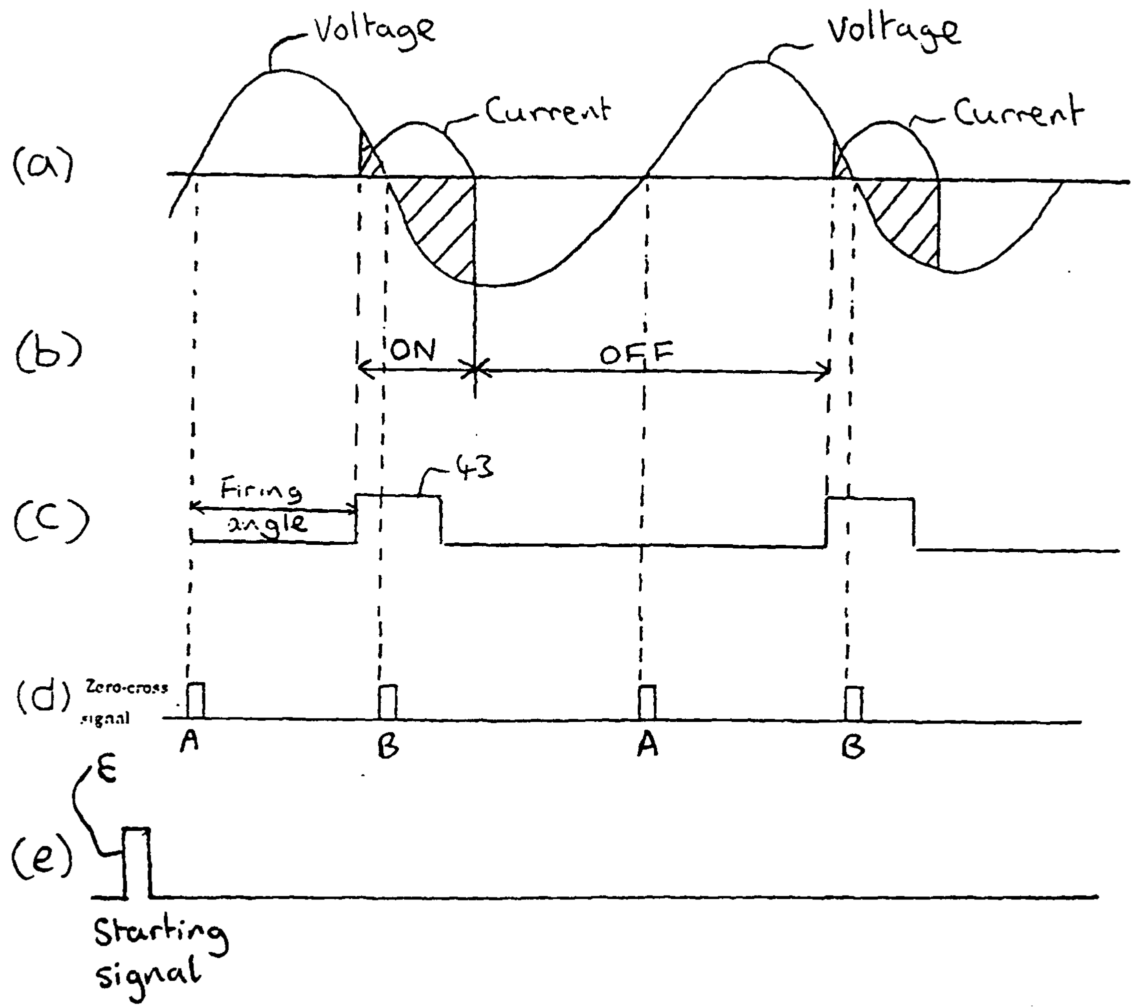

Voltage
Current
Voltage
Current
(a)
(b)
ON
OFF
(c)
Firing angle
43
(d)
Zero-cross signal
A
B
A
B
E
(e)
Starting signal

Fig 6C

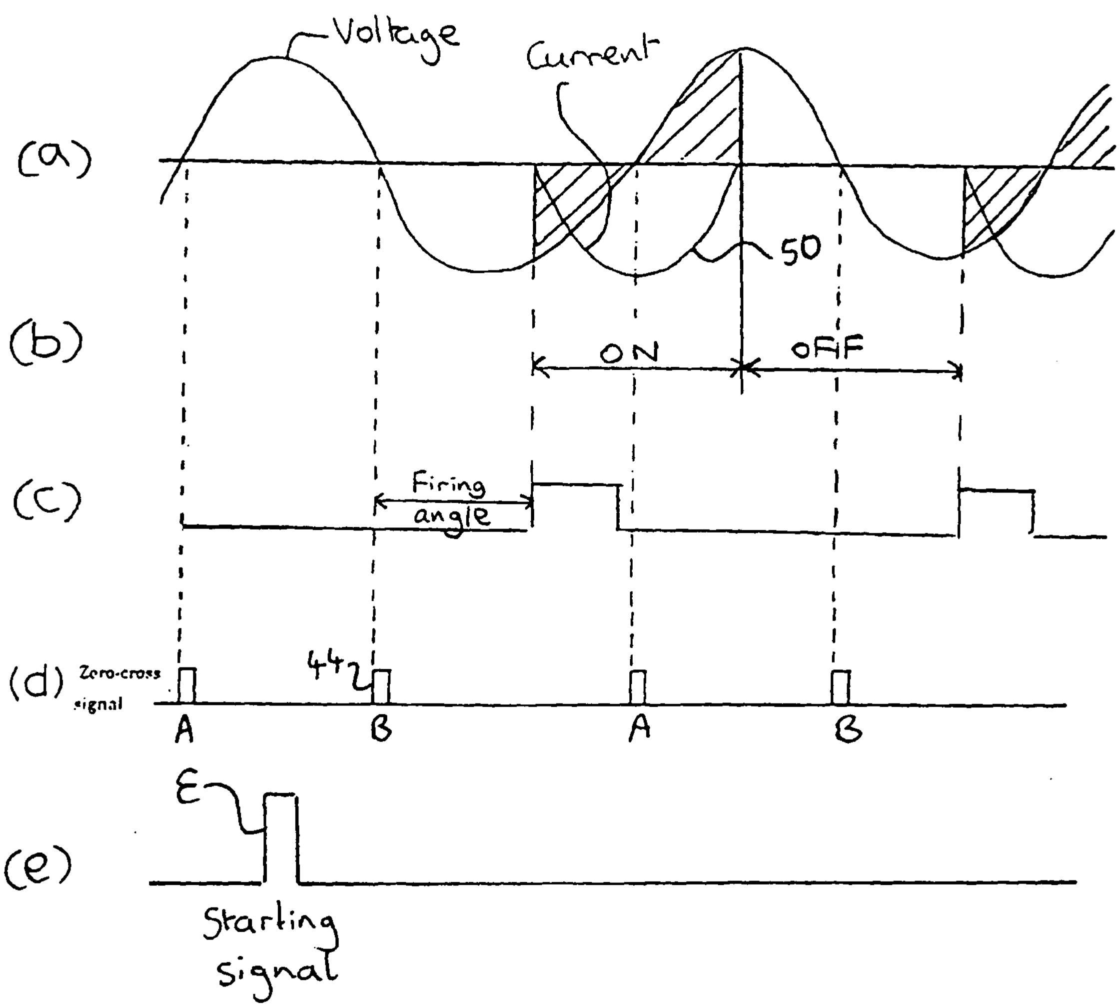

Voltage
Current
(a)
50
(b)
ON
OFF
(c)
Firing angle
(d)
Zero-cross signal
44
A
B
A
B
E
(e)
Starting signal

Fig.7

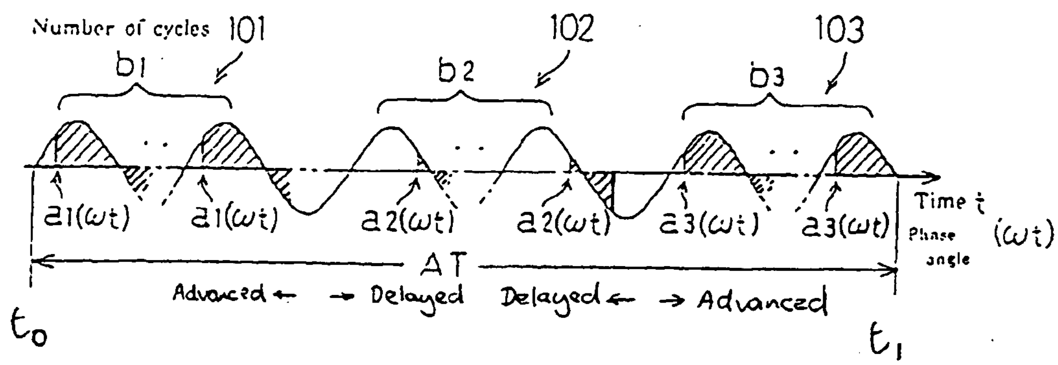

Number of cycles
101
102
103
b1
b2
b3
a1(ωt)
a1(ωt)
a2(ωt)
a2(ωt)
a3(ωt)
a3(ωt)
Time t
Phase angle
(ωt)
AT
Advanced ← → Delayed
Delayed ← → Advanced
t_0
t_1

Fig.8

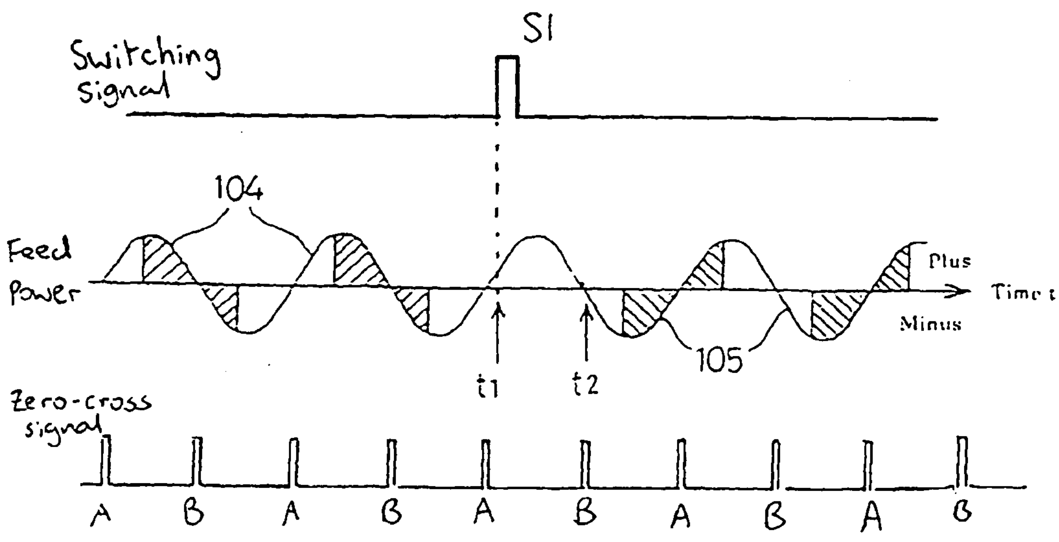

S1
Switching signal
104
Feed Power
Plus
Time t
Minus
105
t1
t2
Zero-cross signal
A B A B A B A B A B

Fig.9